Space Weather Technical Forecast

Issued on Monday, 03 April 2023 at 13:17 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of Minor Geomagnetic Storms Days 1-3. Periods of Active electron fluence expected. Slight chance of M-class flares (R1-R2; Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with several small C-class flare observed just before midnight. The peak being a C3.4 flare at 02/2313 UTC from newly numbered AR3270. There are currently four numbered sunspot regions on the disc. Most are small and simple with little magnetic complexity. However, newly emerged AR3270 continues to slowly grow and contains a number of small intermediate spots of opposing polarity in relatively close proximity. The analysis and modelling of Coronal Mass Ejections (CMEs) detected in available imagery over the past 24 hours suggest no significant Earth-directed component.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by ACE and DSCOVR, started the period at Elevated levels, with solar winds initially at 530 km/s due to the ongoing enhancement from Coronal Hole 88/-. Later in the UTC day on the 2nd, solar winds declined to Slightly Elevated levels (and are now around 480km/s) suggesting waning influence of this feature at Earth. Density was below average and the phi angle negative (towards the Sun). The IMF was weak (below 8nT), and the north-south component was also weak with fluctuations between +5/-5nT. Geomagnetic activity remained at Quiet to Unsettled (Kp1-3) levels.

Energetic Particles / Solar Radiation: High energy proton enhancement (greater than 10MeV) has been at background levels. The high energy electron flux (greater than 2MeV), as measured at GOES16 has varied diurnally between Normal Background and mainly Moderate levels, and has now reached High levels from around 03/0400 UTC. The associated 24-hour fluence has remained just below the Active (1e8 integrated pfu) threshold and is now steadily rising towards the active threshold. At 03/0001 UTC the observed fluence was 4.29e7 integrated pfu, which happened to be its nadir level.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to continue at Low levels, with a Slight Chance of becoming Moderate, should a more significant flare occur and this currently has a probability of 15%.

Solar Wind / Geomagnetic Activity: Although no significant Earth-directed CMEs are expected, there is a slight chance of glancing blows from one or more CMEs at Earth on Days 1 and 2 (03 and 04 Apr). Solar winds are likely to remain at predominantly Slightly Elevated levels for Day 1 (03 Apr), although this may be complicated by any transitory CME impacts. On Days 2-3 (04-05 Apr) Earth is expected to connect to the HSS from one or more coronal holes. Solar winds are expected to return to Elevated or perhaps Strong levels and continue into Day 4 (06 Apr). Generally Quiet to Unsettled geomagnetic activity is expected on Day 1 with a chance of Active intervals or perhaps isolated G1/Minor Storm conditions, particularly should any CME effects occur. There is an increasing probability of Active or G1/Minor Storm intervals on Day 2 due to the combined influence of coronal hole HSS and possible transitory CME effects. Activity should generally become Unsettled by Days 3 and 4 with a reducing risk of Active or G1/Minor Storm conditions in the absence of any further

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CMEs.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES-16 is at background levels and is expected to remain so pending any significant sunspot development. The flux at GOES16 is currently at High levels. There is a very slight chance that CME influences could suppress observed flux values temporarily back towards Normal Background, adding uncertainty into the forecast early in the period. As the HSS from one or more coronal holes affects Earth from Day 2 (04 Apr) and perhaps also a glancing blow from another CME, it is likely that flux values return to Normal Background levels for a period. Electron counts would be expected to rise again into Day 4 (06 Apr) as geomagnetic activity likely subsides, bringing an increased chance of High electron flux levels being reached.

Confidence in the associated electron fluence levels is lower than usual given the uncertainty in any CME and HSS impacts during the period. Fluence levels are currently just below the Active threshold, but are forecast to rise through the active threshold in the next 24 hours however this is ahead of any reduction due to the onset of geomagnetic activity associated with one or more coronal hole HSS. Electron fluence may then reach Active levels once again by Day 4 as Geomagnetic activity subsides.

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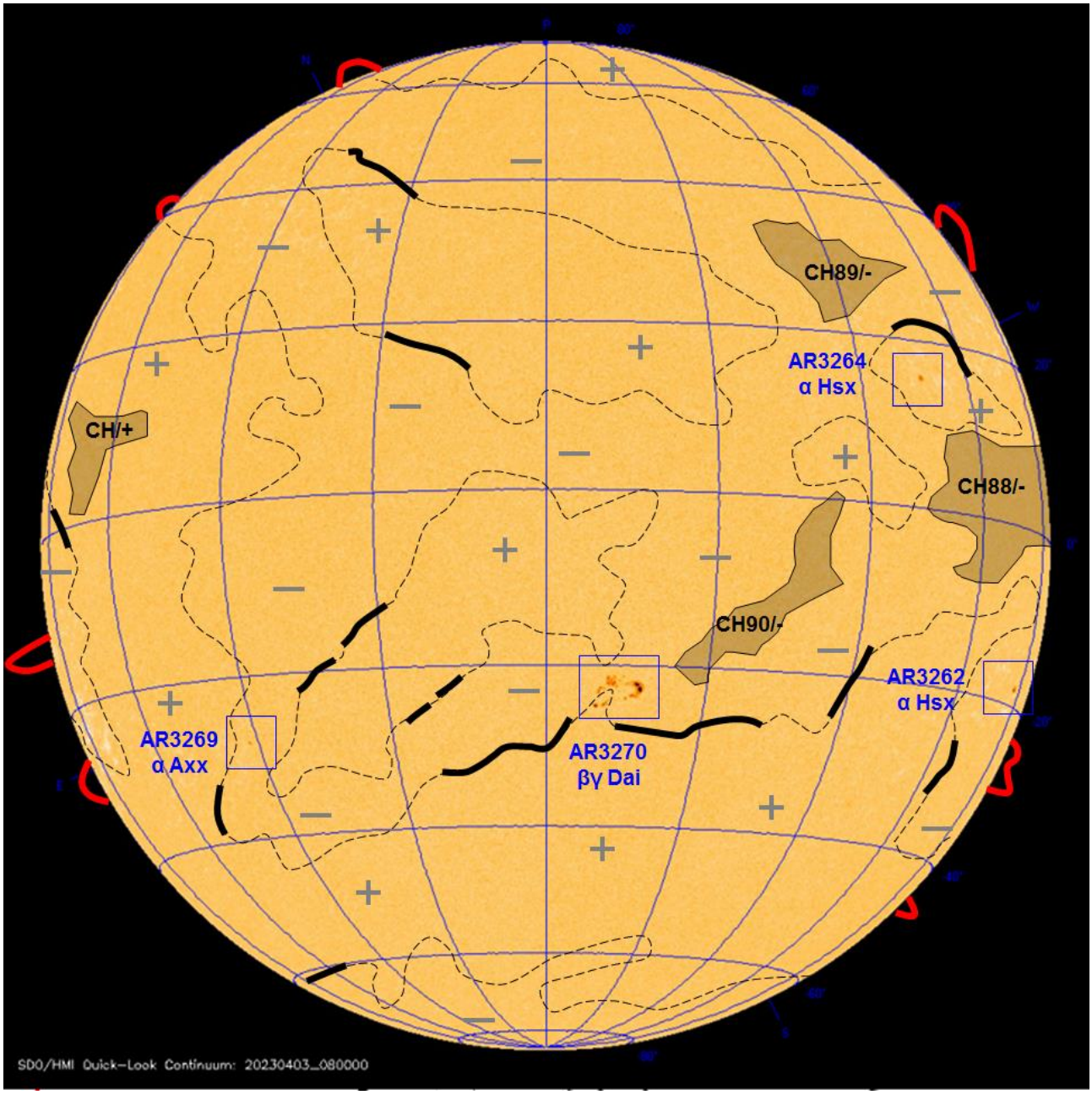
Figure 1. Solar Analysis Valid 0800UTC, 3 April 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

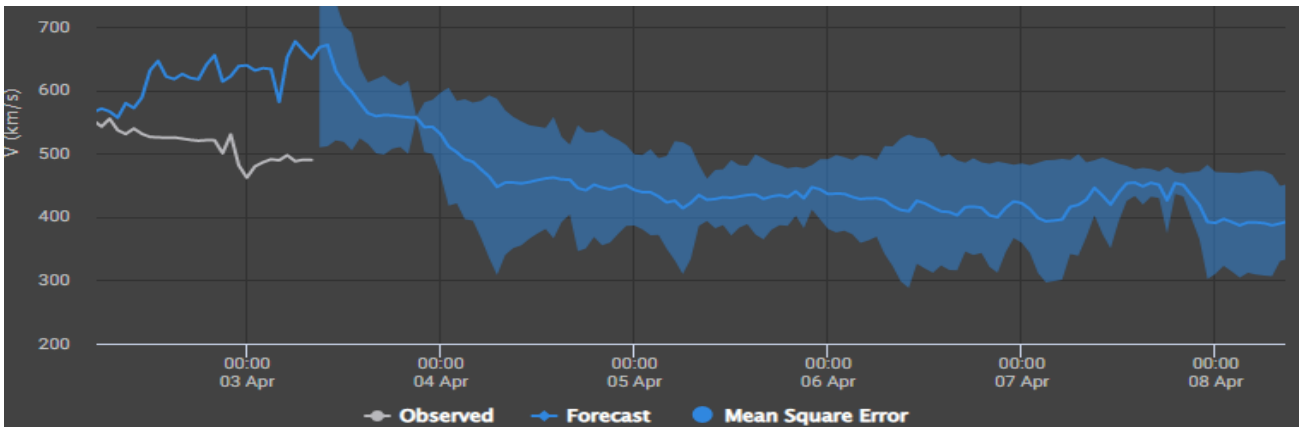
There have been a number of generally small, but complex to analyse CMEs over the last few days. Although modelling would suggest that these are not Earth-directed, there remains a slight chance of glancing blows arriving at Earth on Day 1 and 2 (03 and 04 Apr), supported by a small number of MOSWOC ENLIL ensemble perturbations, however any impacts will most likely be minor. Solar winds are currently at Slightly Elevated levels, a result of the ongoing (but waning) influence of a HSS from CH88/-. Solar winds are likely to continue Slightly Elevated on Day 1 (03 Apr), although this may be complicated by any transitory CME impacts. On Days 2-3 (04-05 Apr) Earth is expected to connect to the HSS from Coronal Holes 89/- and/or 90/-, with CH90/- in the southern hemisphere expected to be the dominant feature. Solar winds are forecast to return to Elevated or perhaps Strong levels and this will probably continue into Day 4 (06 Apr). Currently the Met Office Enlil model output appears to be covering this well. Generally Quiet to Unsettled geomagnetic activity is expected on Day 1 with a chance of Active intervals or perhaps isolated G1/Minor Storm conditions, particularly should any CME effects occur. There is an increasing probability of Active or G1/Minor Storm intervals on Day 2 due to the combined influence of coronal hole HSS and possible transitory CME effects. Activity should generally become Unsettled by Days 3 and 4 with a reducing risk of Active or G1/Minor Storm conditions in the absence of any further CMEs.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	40	20	10
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: Met Office Solar Winds Prediction Model (SWPM) indicating slightly elevated to elevated solar winds.



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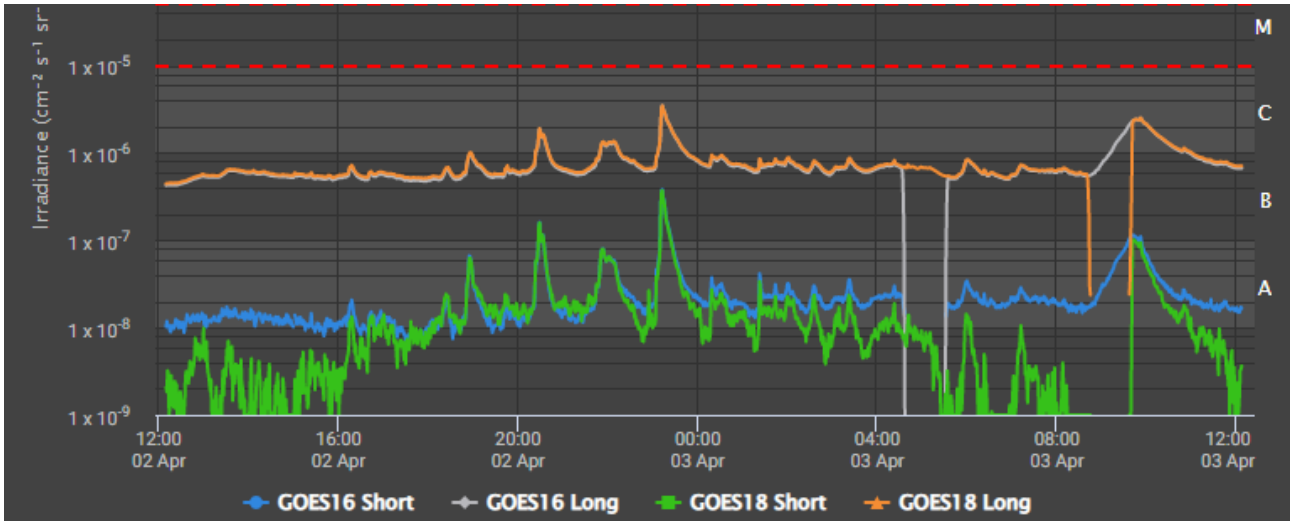
Radio Blackouts - X-Ray Flares:

The four-day forecast period is currently expected to see a fairly muted flare risk due to the presence of a small number of generally simple regions on the visible disc. AR3270, however, will continue to be closely monitored and further development could see an increase in significant flare probabilities through the period. There is an indication for returning or new regions to arrive across the eastern limb during the period. Soundings suggest the most active of these regions may emerge in the northern hemisphere on Day 2 or 3 (04 or 05 Apr) with an associated uptick in forecast flare risk.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	15	20	20	15
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 3: X-ray flux plot at GEO with observational data provided from GOES, with several C-class flares.



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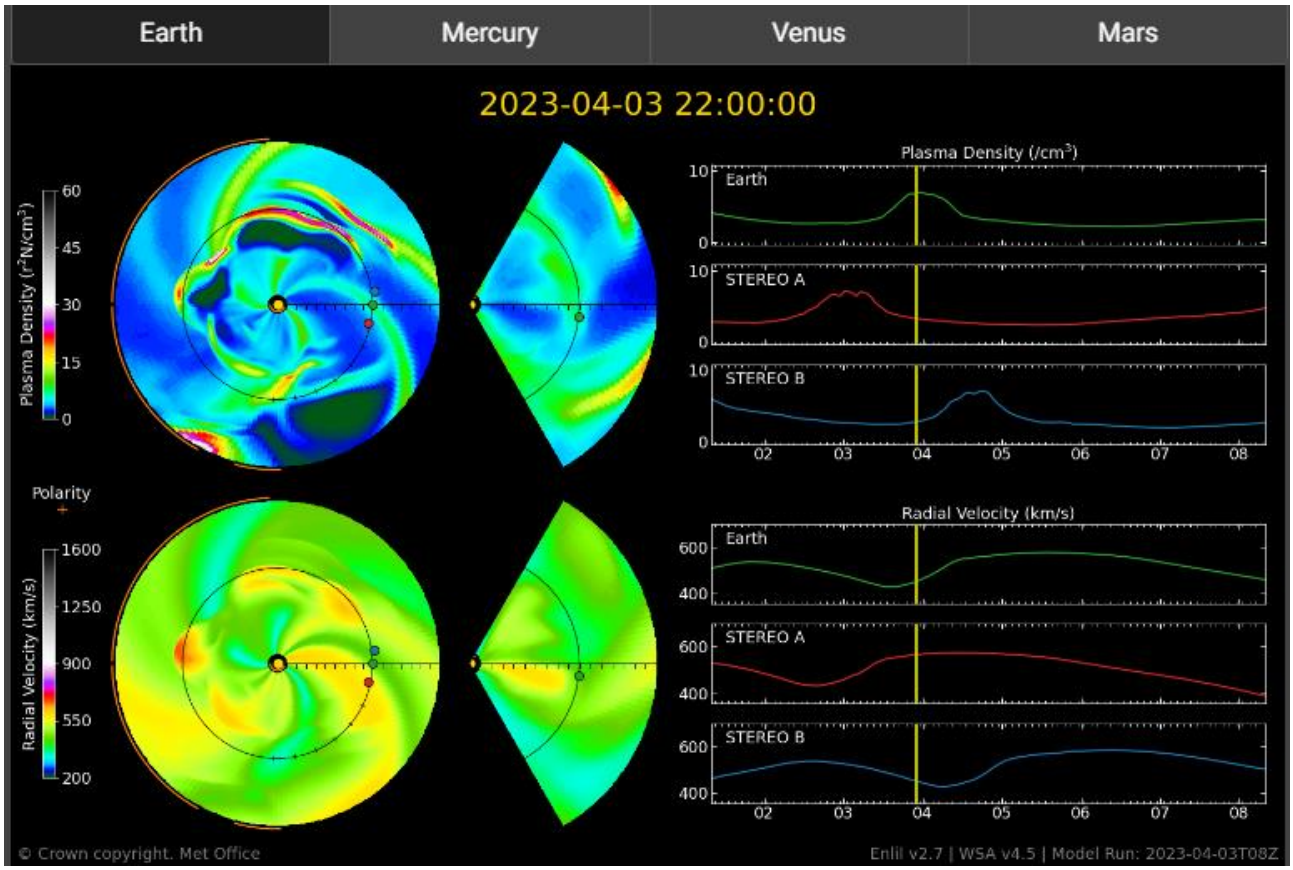
Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV), as observed by GOES-16 is forecast to remain at background levels, pending any significant sunspot development. Any significant flare activity from AR3270 gives the greatest risk of levels reaching S1.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: Met Office ENLIL output showing a number of CMEs that are not Earth directed.



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High Energy Electrons Event (≥ 2MeV):

The flux at GOES16 is at High levels to start the period. There is a slight chance that CME influences could suppress observed flux values temporarily back towards Normal Background, adding uncertainty into the forecast early in the period.

As the HSS from CH89/- and/or CH90/- affects Earth from Day 2 (04 Apr) and perhaps also a glancing blow from another CME, it is likely that the electron belts will be compressed and flux values return to Normal Background levels for a period. Electron counts would be expected to rise again into Day 4 (06 Apr) as geomagnetic activity likely subsides, bringing an increased chance of High electron flux levels being reached.

Confidence in electron fluence levels is lower than usual given the uncertainty in any CME and HSS impacts during the period. Fluence levels are currently just below the Active threshold, but are expected to increase to Active levels on Day 1 and likely persist early on Day 2, ahead of any reduction due to the onset of one or more coronal hole HSS. Electron fluence may then reach Active levels once again on Day 4 as Geomagnetic activity subsides.

MOSWOC REFM output is currently under-forecasting fluence levels, and it is likely that levels as shown by recurrrence will most likely reflect expectations in the coming days.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	60	70	40	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output showing increasing activity.

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